Vertical *vs* Horizontal Crossing in IP5

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The effect of the IP5 crossing plane orientation on energy deposition in the inner triplet is shown. The results of power density calculations with the MARS14 code [1] are given for the nominal luminosity of 10^{34} cm^{-2}s^{-1} at $\sqrt{s}$=14 TeV for a half crossing angle α=150 μrad. All the details of the current design – including optimized TAS, TASB and Q1-MSBX absorbers, slide bearing masks etc [2] – are in the MARS14 model as shown in Fig. 1. Two high-statistics runs have been performed: for the horizontal and vertical crossings with the beam screen in Q2A through Q3 as shown in Fig. 2. All the other parameters in these runs are the same.

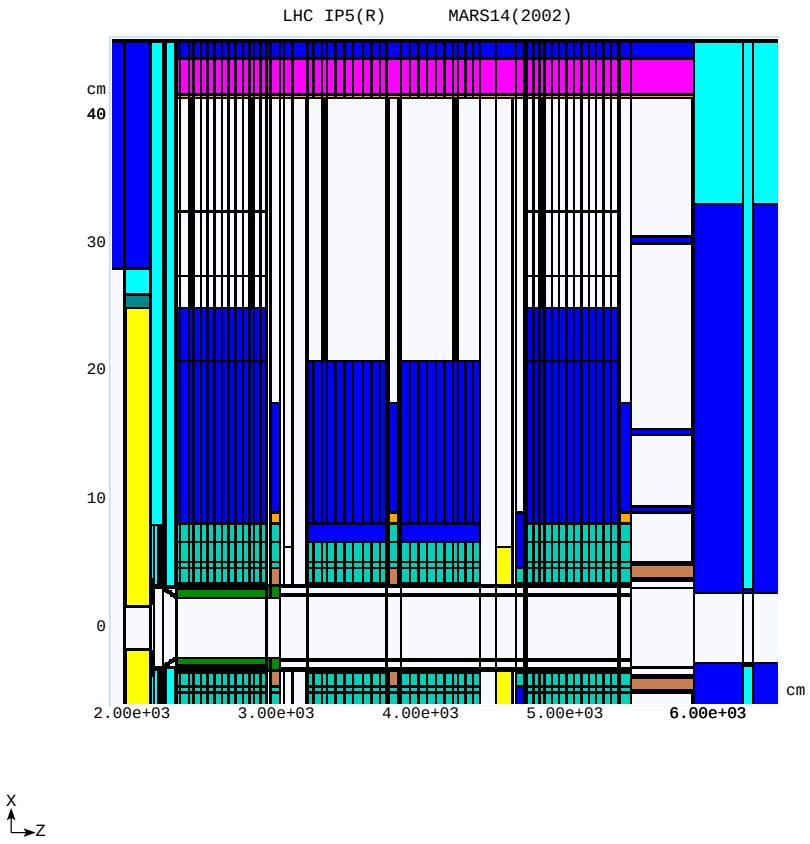

Figure 1: IP5 low-β insertion MARS model.

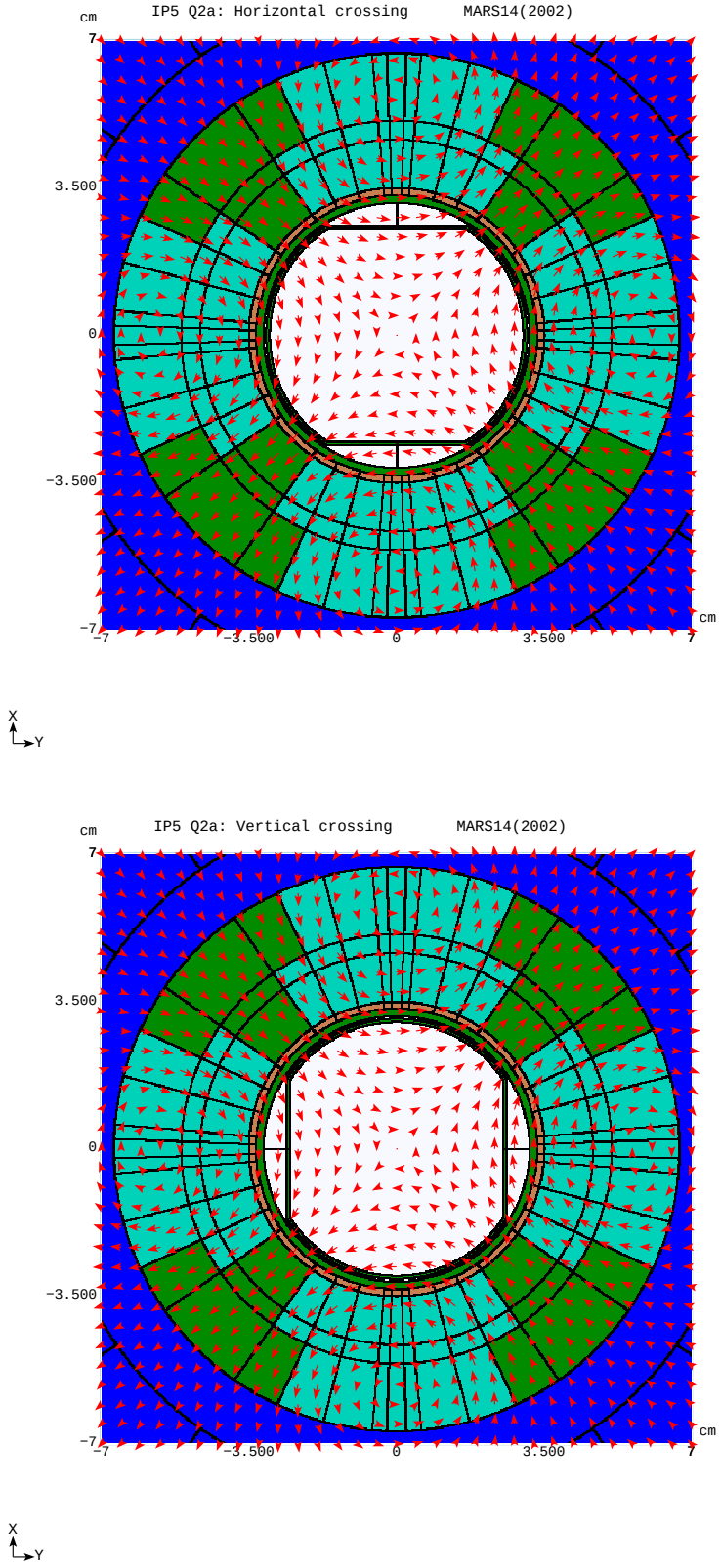

Figure 2: IP5 Q2A MARS model for the horizontal (top) and vertical (bottom) crossings.

Figs. 3–4 show azimuthal distributions of power density in the IP5(R) quadrupole coils at the hottest (longitudinally) spots, calculated both for horizontal and vertical crossings. One sees pronounced peaks in the horizontal and vertical planes, with a difference between maximum and minimum values reaching a factor of 10 and between the peaks and azimuthally averaged values of a factor of 2.5 to 5.5.

A longitudinal distribution of an azimuthal peak in the first radial bin of the SC coils ($35<r<46.5$ mm) in the IP5(R) inner triplet is shown in Fig. 4 (bottom). For the baseline horizontal crossing, the power density reaches its maximum ε_{max} at the Q2B non-IP end. For the vertical crossing, there are two equal peaks – at the IP end of Q2A and at the non-IP end of Q3 – which are slightly lower than the one for the horizontal crossing case.

Thanks to the protective measures implemented into the inner triplet design [2], one keeps peak power density ε_{max} a factor of about three – at the baseline luminosity – below the LHC high-gradient quadrupole quench limit of 1.2 mW/g, both for horizontal and vertical crossings in the IP5 with appropriate orientation of a "racetrack" beam screen. Note that the above limit is assumed in the project for last seven years and was recently updated to 1.6 mW/g for MQXB on the basis of thorough thermal analysis of the Fermilab quadrupoles [3].

References

[1] N.V. Mokhov, "The MARS Code System User's Guide", Fermilab-FN-628 (1995); N. V. Mokhov, O. E. Krivosheev, "MARS Code Status", Proc. of the Monte Carlo 2000 Conference, Lisbon, October 23-26, 2000, Springer, p. 943; Fermilab-Conf-00/181 (2000); http://www-ap.fnal.gov/MARS/

[2] N.V. Mokhov, I.L. Rakhno, J.S. Kerby, J.B. Strait, "Protecting LHC IP1/IP5 Components Against Radiation Resulting from Colliding Beam Interactions", Fermilab (2002).

[3] A. V. Zlobin *et al.*, EPAC'02 proceedings, MOPLE017 (2002).

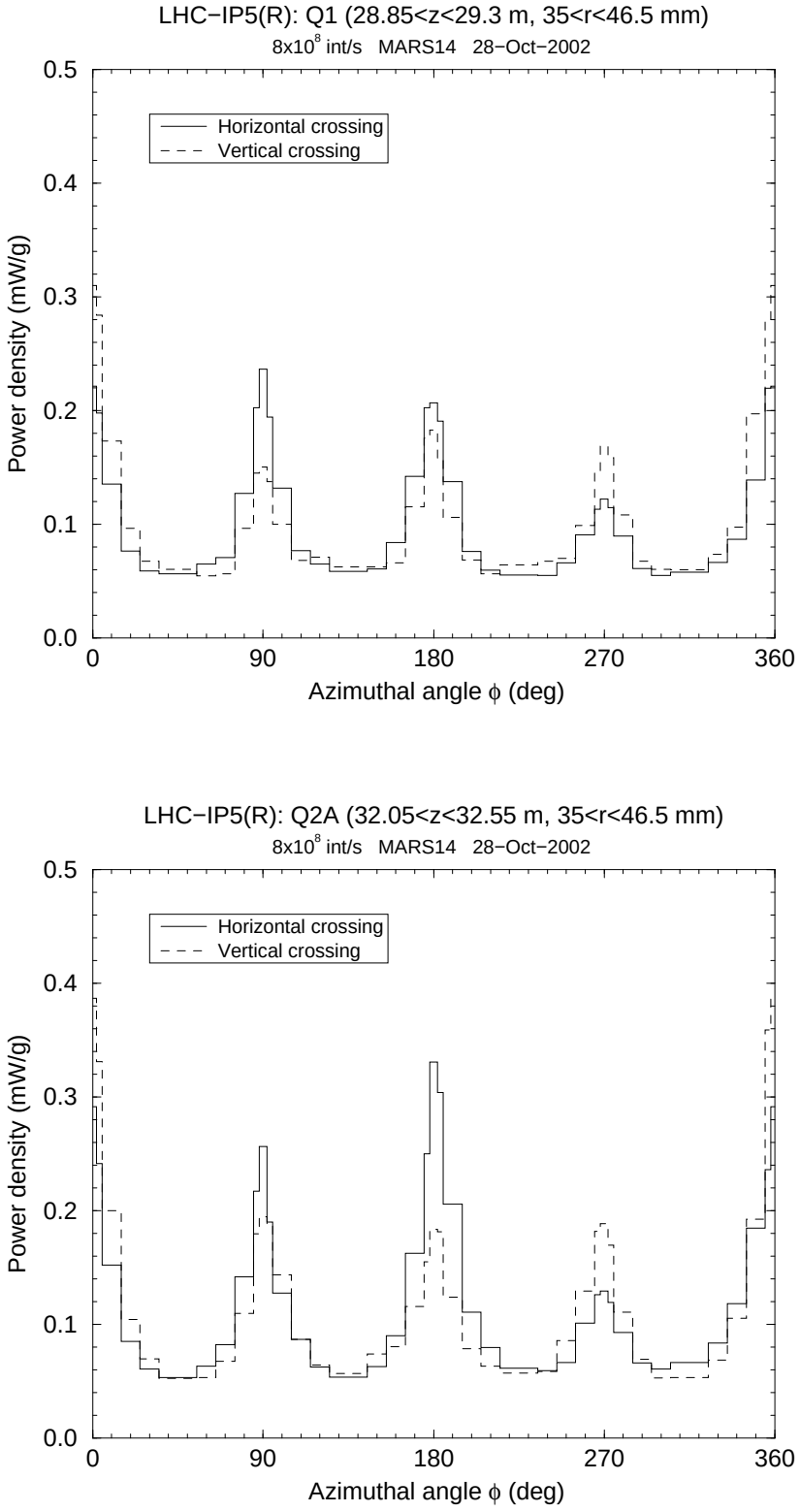

Figure 3: Azimuthal distributions of power density in the first radial bin of the SC coils in the IP5 Q1 (top) and Q2A (bottom) quadrupoles at longitudinal peaks for the horizontal and vertical crossings.

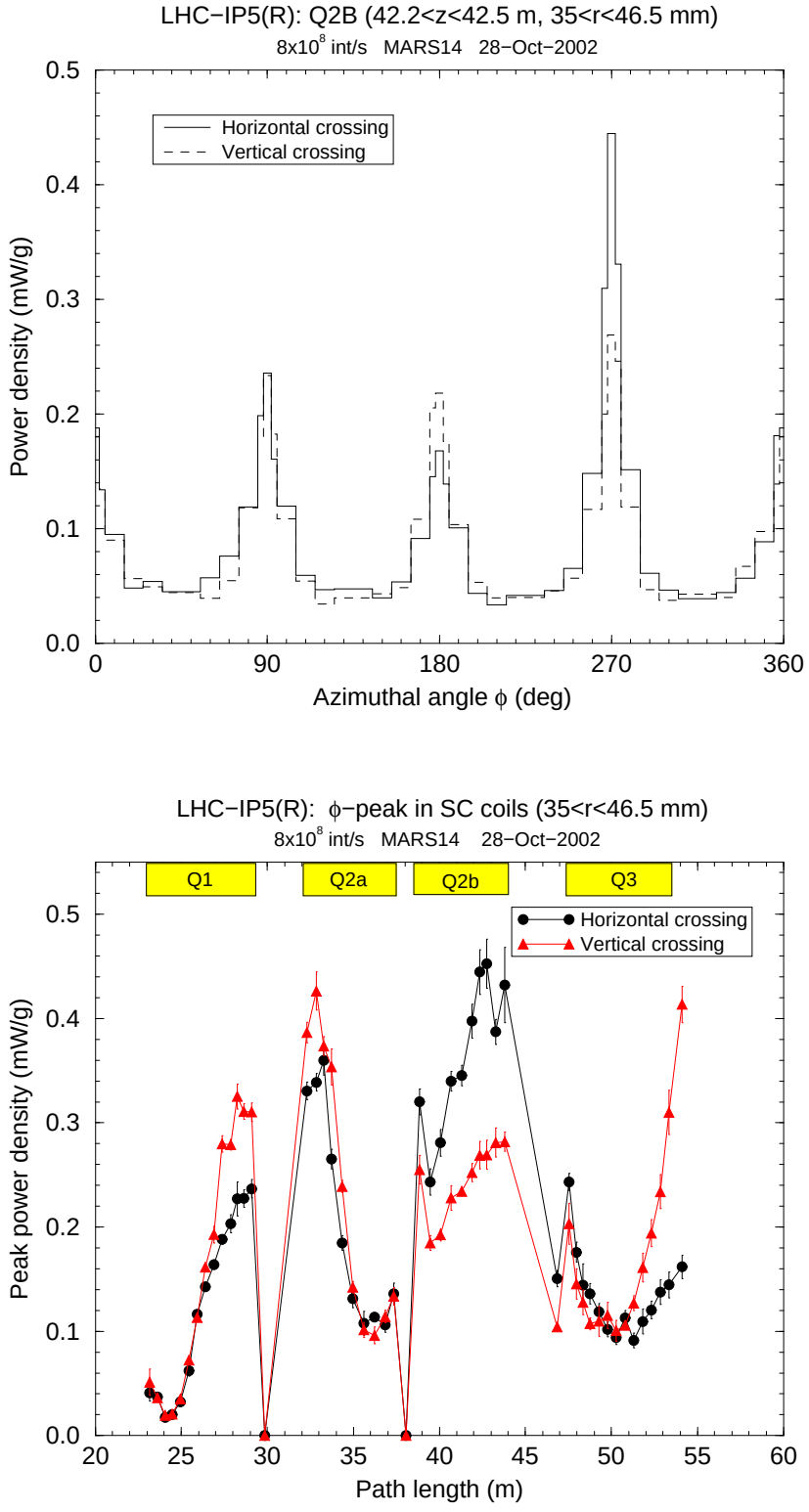

Figure 4: Azimuthal distribution of power density at longitudinal peak in Q2B quadrupole (top) and longitudinal distribution of peak power density (bottom) in the first radial bin of the IP5 SC coils in the IP5 quadrupoles for the horizontal and vertical crossings.